In April 2010, the United States, Canada, Spain, South Korea, and the Bill and Melinda Gates Foundation agreed to pool resources for a new multilateral agriculture and food security program (The World Bank/Simone D. McCourtie)

Debunking Technical Competency as the Sole Source of Innovation

By Burton H. Catledge

The inadequacies of our systems of research and education pose a greater threat to U.S. national security over the next quarter century than any potential conventional war that we might imagine. American national leadership must understand these deficiencies as threats to national security.

—Road Map for National Security: Imperative for Change

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Academic and governmental organizations have sounded the alarm that the United States is rapidly losing technical competence, and this decline places the Nation at risk. A 1983 National Science Foundation (NSF) report stated, "If an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might well view it as an act of war."[1] In 1999, Congress chartered

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Figure.

the U.S. Commission on National Security/21st Century (also known as the Hart-Rudman Commission) to provide the most comprehensive Government-sponsored review of U.S. national security in 50 years. The report highlighted a lack of U.S. technical competence as a national security threat second only to the threat of weapons of mass destruction in the hands of terrorists.[2] This article attempts to answer the question: "Does improving technical competency enhance innovation?"

The Hart-Rudman Commission report and many others argue that technical competence is a prerequisite for innovation. Producing technically competent Americans in science, technology, engineering, and mathematics (STEM), according to such reports, would stimulate innovation. *Technical competence* refers to technically trained people with a high level of knowledge and skill related to one or more specific technologies or technical areas.[3] Technically competent individuals are typified as those who have received post-secondary STEM degrees. A lack of U.S. STEM-credentialed personnel and the subsequent technologies they produce threatens national security. For the purposes of this article, *national security* is broadly defined as success on the battlefield.

The figure illustrates the argument that technical competency drives innovation. The subsequent claim is that improvements in innovation will result in enhanced national security. If technical competency does not lead to innovation or innovation does not improve national security, then technical competency claims are unsupported. The primary drivers for increasing technical competency are the National Academy of Sciences (NAS) and similar scientific and defense organizations.

The role of technology and its influence on society are controversial. To some, technology increases the carnage of war, while others hail it as the savior of humankind. The United States tends toward the latter view. American history is replete with examples of technology positively influencing society. Technologies such as the railroad, telegraph, and steamboat provided the means to settle vast territory. Thomas Edison's electric light permitted work past sunset and hence increased productivity and output. The automobile and aircraft opened opportunities for Americans to explore the United States and the world. These technologies and the resulting improvements in quality of life were equated with progress, a relationship that has driven the Nation to elevate the role of those who give us that progress. According to a 2007 survey, 86 percent of Americans believe that the United States must increase the number of workers with science and mathematics backgrounds, or else the country's ability to compete in the global economy will be diminished.[4] Consider the closing statement in the NAS report titled *Rising Above the Gathering Storm*:

> *For the first time in generations, the nation's children could face poorer prospects than their parents and grandparents did. We owe our current prosperity, security, and good health to the investments of past generations, and we are obliged to renew those commitments in education, research, and innovation policies to ensure that the American people continue to benefit from the remarkable opportunities provided by the rapid development of the global economy and its not inconsiderable underpinning in science and technology.*[5]

The technical competence of a nation can be measured in science and engineering degrees awarded, basic research investment in research and development (R&D), patents filed, and STEM articles published. The assumption that technology is the single greatest factor to progress has misled the American public into believing that STEM-credentialed personnel are the source of technology and that a decline in technical competency translates into a decline in progress.

Historical Patterns

There are historical precedents for policymakers and scientific organizations overreacting to perceived declines in U.S. technical competency. The pattern of declining technical competency starts with a perceived threat from another country, followed by an American outcry for improving the U.S. educational system and scientific research, only to discover later that the threat was not as dire as originally perceived. This cyclical nature of diminishing technical competency is not unique, and the roots of these warnings can be traced as far back as the late 1950s. In 1957, for instance, the Soviet Union was perceived as having a strategic advantage in the larger numbers of scientists and engineers in Soviet universities and technical institutes.[6] Following the launch of Sputnik, the U.S. Government expanded Federal support for research and education in science, mathematics, and engineering.[7] American educators at the time decried the educational system as too focused on extracurricular activities, while depicting the Soviet Union as superior in science and engineering. A Senator announced that the Soviet Union was training more scientists than any other Western nation, while an aide to Lyndon Johnson warned that Russia had 350,000 high school science and math teachers compared to 140,000 in the United States. Admiral Hyman Rickover, the dour "Father of the Nuclear Navy," hoped Sputnik would spark a revival of American intellect in the same way that the attack on Pearl Harbor catalyzed the military-industrial complex.[8] The Secretary of Health, Education, and Welfare highlighted that all Russian students took 5 years of physics and math and 4 years of chemistry. Only one in four American students even took a physics course, and just one in three took a chemistry class.[9]

In response to this perceived educational gap, the National Defense

Education Act (NDEA), passed by Congress in 1958, authorized spending slightly less than $1 billion over a 4-year period to strengthen the Nation's educational system to compete with the Soviet Union. According to Roger Geiger in *Research and Relevant Knowledge*, the "NDEA was prompted by the peculiar attitude of national insecurity and inadequacy that prevailed after Sputnik."[10] Congress declared that Federal action was required to address the "educational emergency" and "to help develop as rapidly as possible those skills necessary to national defense."[11]

The Federal Government also tried to bolster American technical competency with direct investments in scientific research. Federal investment in R&D between 1957 and 1967 more than doubled, and total government outlays for basic research at the NAS and other agencies tripled.[12] In reality, the Soviet Union was not producing scientists, but training technicians.[13] Although the Soviet threat was overblown, Sputnik and the subsequent NDEA enlarged the capacity of research universities that became increasingly dependent on the Federal Government for financial support.[14]

By the 1980s, American fears about declining technical competency focused on the threat posed by Japan and its growing export-led economy. The press and academia amplified these concerns, and Congress responded by increasing the NSF's science and mathematics budget substantially.[15] Once again, the Nation overreacted to a perceived threat, and within a few years the Investigations and Oversight Subcommittee of the Science, Space, and Technology Committee of the House of Representatives reported that there was an excess supply of newly minted scientists and engineers.[16]

By the 1990s, multinational companies working in high-tech sectors such as software, information technology, and telecommunications were claiming another STEM personnel shortage.[17] Companies were experiencing difficulty hiring skilled workers. Their claims about the looming personnel shortage, however, were not verified by other sources.[18] The current concern about U.S. STEM deficiencies echoes previous claims of shortages.

The Federal Government and industry have had difficulty making accurate predictions about future personnel demands. A National Research Council panel of experts evaluated the success of past forecasts for the 2000 science and engineering workforce estimates. The council reported that labor market projections for scientists and engineers that go more than a few years into the future are notoriously difficult and that "accurate forecasts have not been produced."[19]

Alternative Contributors to Innovation

The shortage of personnel evokes a strong U.S. reaction primarily because of the perception that innovation is based on a single factor. This single-factor method reduces a complex phenomenon into one cause and relegates other factors, such as social elements, to secondary importance.[20] The single-factor method offers a simplistic approach in identifying a cause-and-effect relationship; however, the role of technology in innovation is not as straightforward as this method prescribes. By limiting the cause-and-effect relationship to a single factor, there is great potential to overlook alternative contributors to innovation.

Technical competency proponents employ a single-factor method when they highlight the role of STEM-credentialed personnel in the innovation process at the expense of other contributing factors. However, scientists and engineers cannot be the right single factor because these groups tend to avoid the anomalies that may result in innovations. A recent article in *The Economist* claims, "Scientists' role in innovation seems obvious: The more clever people there are, the more ideas are likely to flourish, especially if they can be commercialized."[21] Although society considers them creators, designers, and researchers, these individuals tend to form conservative, rather than innovative, social groups. These groups, or communities of practice, are not necessarily more innovative that those outside the community.

The evidence that science communities of practice are more conservative and tend to coalesce is highlighted in Thomas Kuhn's *The Structure of Scientific Revolutions*. His central thesis is that scientific communities tend to conduct science that proves the established norm or paradigm, rather than discovering groundbreaking innovations. Kuhn uses the term *normal science* to describe research based on one or more past scientific achievements that a particular scientific community acknowledge as its foundation.[22] Kuhn states, "The most striking feature of normal research problems is how little they aim to produce major novelties."[23] As a result, most scientists assume that they already know what the world is like, and research typically reaches conclusions confirming these scientists' anticipated outcomes.[24] Normal science does not attempt to discover and investigate anomalies, and, when conducted successfully, it finds none.[25] Scientists and engineers contribute to innovation, but they are not its single source.

Rather than being unbiased and objective thinkers, scientists will anticipate research conclusions because of past training. Members of the scientific community, more than most other fields, have undergone similar education and professional initiations, been exposed to the same technical literature, and drawn many of the same lessons.[26] Kuhn continues, "One of the fundamental techniques by which members of a group . . . learn to see the same things when confronted with the same stimuli is by being shown examples of situations that their predecessors in the group have already learned to see as like each other and as different from other sorts of situations."[27]

If scientists and engineers were the single factor driving innovation, the expectation would be that innovation would only come from this community. However, innovation can and often does result from ideas outside the community of practice. Edward Constant, in *The Origins of the Turbojet Revolution*, offers such an example of innovation resulting from outside the expected community. Conventional wisdom held that aircraft

performance could be improved by modifying the existing aeronautical design with supercharged liquid-cooled piston engines, turboprops, higher octane fuel, and sleeker aircraft structures to increase performance. The aeronautical community of practice, however, required a completely new aeronautical design that was drastically different from the conventional wisdom. This design would not come from the expected community of practice. Constant cites the fact that four men, geographically separated and with diverse backgrounds outside the normal aeronautical community, produced the turbojet engine.[28] Narrow communities of practice, such as the aeronautical community, tended to overlook the anomalies that could have provided the important sources of innovation within their fields.

The theory that increasing the number of STEM-credentialed personnel increases innovation is not an *iron law of science*. Scientists do not evaluate research with unbiased and objective lenses, but their communities of practice often shape their vision. This vision makes the recognition of anomalies difficult because of similar backgrounds and education. When those anomalies present themselves, those closest to the problem tend to overlook them, while outsiders attempt to explain them. If outsiders are capable of identifying anomalies and translating those insights into innovations, the science and engineering communities of practice cannot be the single source of innovation.

Techno-nationalism

If four men in three countries simultaneously and independently developed the turbojet, how can a nation hope to capture the benefits of its scientific and technical communities? Proponents assume that the United States will be more innovative if it has more technically competent personnel. However, invention only opens a door; it does not compel one to go through it. The acceptance or rejection of an invention depends on the condition of a society, imagination of its leaders, and nature of the technology itself.[29] Nations do not necessarily exploit the benefits of inventions developed within their borders. The internal combustion engine was first produced in Germany, but that country was not the main manufacturer of automobiles within 20 years of the industry's formation. The airplane was invented in the United States in 1903, but Great Britain, France, and Germany capitalized on the invention with larger air fleets by 1914.[30] Although air fleet size alone is not a measure of innovativeness, it does highlight society's willingness to capitalize on an innovation. The underlying assumption of technical competency advocates is that if a nation's community of practice produces an innovation, that innovation will remain within the country's borders. This assumption encourages nations to develop technically qualified personnel and innovations along nationalist lines. This assumption is a variation of nationalistic ideology called *techno-nationalism*.

Nationalism denotes a condition of the mind in which members of a nationality or nation-state express loyalty to that state above all other loyalties and to which pride in one's nationality and belief in its intrinsic excellence and in its "missions" are integral parts.[31] In other words, nationalism is an ideology that promotes a country's accomplishments as superior compared to other nation-states. Three factors must be considered to understand nationalism and its propagation. First, a group of intellectuals must promote a nationalist doctrine. In the case of the technical competency advocates, the intellectuals promoting the nationalistic ideology are U.S. policymakers. Second, these citizens typically find satisfaction and refreshment for their souls (and often their pocketbooks) in this doctrine. Since the Federal Government is the single largest source of basic research funding, organizations such as the NAS must continue to emphasize threats to U.S. science and engineering superiority. As mentioned earlier, fears that the United States was losing its technological advantage as compared to the Soviet Union, Japan, China, and India have all resulted in large infusions of government funds into science and engineering organizations. After Sputnik, for instance, scientists urged President Dwight Eisenhower to appoint a Presidential Assistant for Science and Technology to increase the funding of NSF grants in fiscal year 1958 from $38 million to $55 million.[32] Curiously, the organizations emphasizing declining U.S. technical competency today are the same organizations that would receive the greatest benefit from Federal aid. Third, the nationalistic doctrine must find a place in the popular mind by means of "new and curious, but singularly universal, forms of mass-education."[33] One of the consequences of the Sputnik launch was increased Federal funding of science education from $17 million to $53 million in 1958.[34] The three factors that characterize nationalism and its propagation are applicable to the declining technical competency claim.

A techno-nationalist country claims that it is best suited for the technology age.[35] Citizens of a techno-nationalist country tend to view their country as technologically superior to other nation-states. The techno-nationalist country can also be threatened by other nations that demonstrate a technical capability or capacity that threatens its superiority. In the 20th century, the United States characterized the Soviet Union, Japan, China, and India as technological competitors, and this competition stirred a nationalist need to innovate. According to David Edgerton, "Techno-nationalism assumes the key unit of analysis for the study of technology is the nation: nations are the units that invent, that have R&D budgets, cultures of innovation, that diffuse, that use technology. The success of nations, it is believed by techno-nationalists, is dependent on how well they do this."[36]

The claim that the United States must develop more STEM-credentialed personnel is grounded in a techno-nationalistic ideology. The issue is not that there is a dearth of scientists and engineers, but rather that those scientists and engineers are not Americans. If increasing technical competency in the United States was the only dilemma, the science and engineering workforce could be managed with changes in immigration policy. In other words, if all the United

Cecil County math teachers visited Edgewood Chemical Biological Center for Math Forensics where Army scientists demonstrated importance of math in their research and development mission (U.S. Army)

States needed was a more technically qualified workforce, the solution should be to increase the number of foreign-born citizens authorized to work in the United States. However, rather than encouraging workers from abroad to fill positions requiring STEM-credentialed personnel, the United States is seeking to limit the number of foreign workers. In response to immigration reform, technical competency proponents will often cite the U.S. citizenship requirement to fill security-related positions. This could be overcome by changes to American security policies. There is a historical precedent. During World War II, the United States relied heavily on European immigrants to complement its science and engineering workforce. U.S. citizenship and subsequent security requirements could be modified to fill science and engineering positions that require this level of access. Increasing the number of foreign-born citizens filling the technical workforce and modifying U.S. security policy, however, do not satisfy technical competency advocates because the core of the issue is not pragmatism but nationalism. The Hart-Rudman report states:

There will not be enough qualified American citizens to perform the new jobs being created today—including technical jobs crucial to the maintenance of national security. Already the United States must search abroad for experts and technicians to fill the United States domestic economy, and Congress has often increased the category limits for special visas (H-1B) for that purpose. If current trends are not stanched and reversed, large numbers of specialized foreign technicians in critical positions in the United States economy could pose security risks.[37]

More important, however, while the United States should take pride in educating, hosting, and benefiting from foreign scientific and technical expertise, it should take even more pride in being able to educate American citizens to operate their own economy at its highest level of technical and intellectual capacity.

Techno-globalism

The danger of pursuing a techno-nationalist ideology in a globalized marketplace makes the advantages gained from technology extremely perishable. If the United States were to produce an innovative technology, globalization has increased the likelihood that the invention would be replicated and modified by nonproducers of the technology. The United States is proud of its market-driven economy, but it seems reluctant to let market forces guide the development of American STEM personnel.

Today's market-driven economies have produced interdependent world financial markets through globalization. The principal characteristics of globalization are increases in foreign direct investment, intensified international rivalries in technology, and looser trade

Thomas Edison in Washington, DC, April 1878, with his second phonograph (Library of Congress/ Mathew Brady)

restrictions.[38] Globalization has also created technological interdependence that places the techno-nationalist country at a disadvantage. Globalized corporations, which are not limited to national borders, must innovate more rapidly and effectively to remain competitive. The competition between globalized firms results in collaboration across national boundaries, and the fruits of this innovation do not remain within national borders. Conversely, the techno-nationalist country seeks to limit innovation to within its national borders and is therefore in direct conflict with the market economy. This implies that the techno-nationalist country is fighting a losing battle because market incentives tend to encourage innovation. *Techno-globalism* is the term used to describe the impact of sharing technology in a globalized, market-driven economy.[39]

Techno-globalism challenges the country pursuing techno-nationalism. First, the expansion of international trade has made high-tech products available to countries that do not have the technological capacity to produce them. Second, nations are losing control of businesses as they become more transnational through overseas direct investment. If Walmart were a country, it would be China's eighth largest trading partner.[40] The Walmart example emphasizes the difficulty the United States would have in imposing restrictions on multinational firms such as these. Third, many foreign scientists and engineers are trained in the United States and are now working in their native countries. Seventeen of the world's top 20 universities are American, and international students and scholars flock to the United States to enhance their skills and collaborate with American researchers.[41] The education of foreign-born scientists and engineers has created a global diffusion of technical competency leveling the science and engineering knowledge base. Since the diffusion of science and engineering knowledge is already occurring, preventing collaboration across national borders would stifle, not encourage, innovation. Techno-nationalist countries such as the United States, which seek to produce STEM personnel and technologies along nationalistic lines, may invest considerable resources only to discover that globalization offers a greater innovation advantage.

Many 20th-century inventors would not have been predicted to create inventions using the current measures of innovation. STEM advocates would have dismissed Edison when he was 7 years old and described by his teacher as "addled."[42] He was withdrawn from school by his mother and received his education working as a telegraph operator. With no formal education, Edison went on to hold 1,093 patents and produce technologies such as motion picture cameras, the phonograph, and light bulb.

Orville and Wilbur Wright also had atypical backgrounds with no formal education but still produced a significant technological achievement. Orville dropped out of high school in his junior year to start a printing business with his brother, using a damaged tombstone and buggy parts to build a press.[43] The two brothers later opened their own bicycle business, but Wilbur's interest in aeronautics started after reading about a famous German glider pilot. Wilbur's

significant breakthrough was his recognition that in order to fly a machine, its three axes of motion—pitch, roll, and yaw—had to be controlled.[44] Other inventors attempted to develop such a machine; however, on December 17, 1903, an unlikely high school dropout with a printing press and bicycle repair background invented a flying machine that changed the world.

Arguably the most significant innovation in the later 20th century was the personal computer (PC). Interestingly enough, the two individuals most responsible for development of personal computing also had diverse backgrounds with limited formal educations. Steve Jobs and Bill Gates were at the forefront of personal computer innovation, but neither would have been recognized as STEM-credentialed professionals according to current metrics.

Steve Jobs's innovativeness and business sense were not provided by formal education. He dropped out of Reed College after 6 months and along with his friend Steve Wozniak built the first Apple computer in his parent's garage. After leaving Apple in 1985, Jobs started NeXT, which later became Pixar.[45] He revolutionized the smartphone industry with the introduction of the iPhone in 1997, which remains the market leader today.

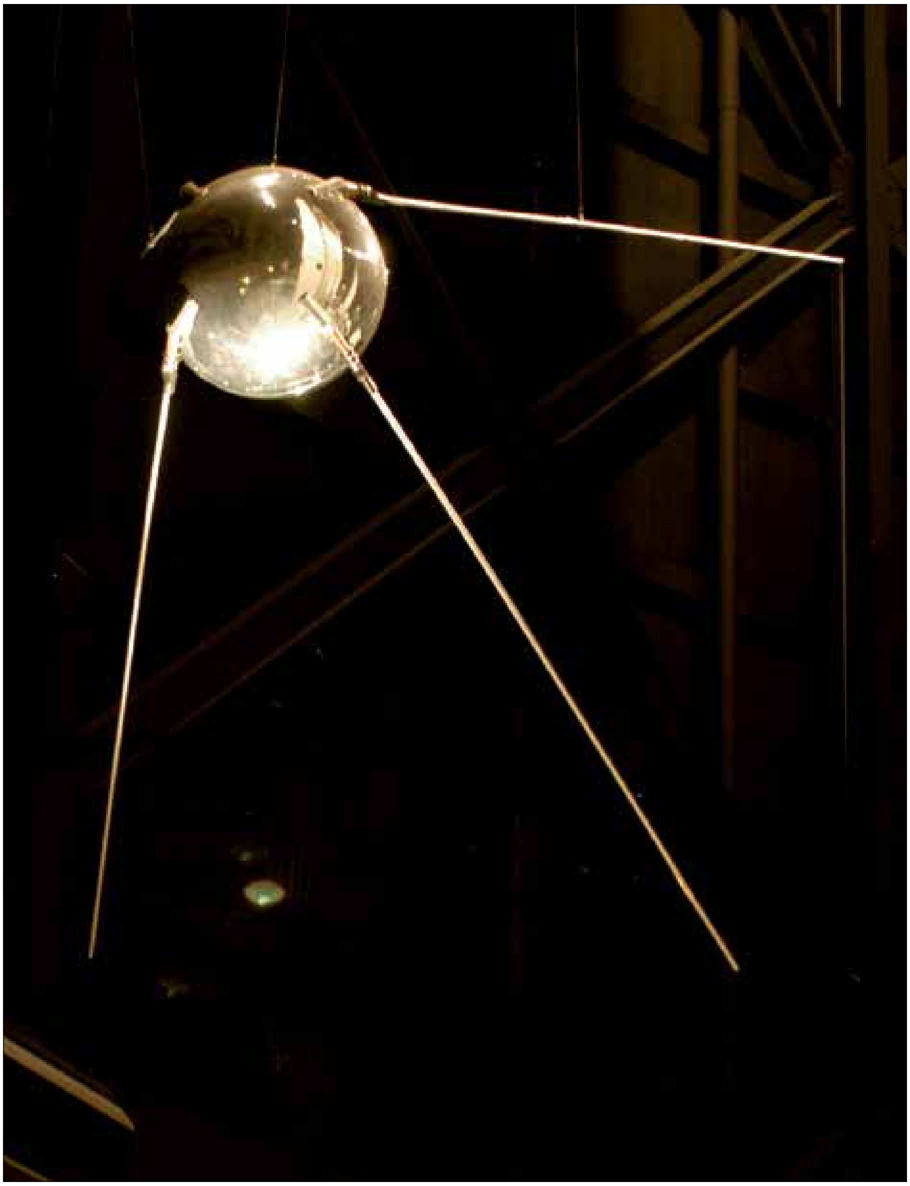
Similar to Jobs, Bill Gates dropped out of Harvard after 2 years to start Microsoft with Paul Allen. Their vision was a computer on every desk and in every home. IBM approached Gates and Allen to develop software to interface with their computer hardware. They programmed the Microsoft Disk Operating System, which became Windows 1.0 in 1985. Since then, Microsoft has released multiple versions of its software, with Windows being the predominant worldwide computer operating system.[46]

Technical competency advocates contend that technological innovation spurs economic prosperity; however, commercialization of innovation can create even greater economic benefits. Edison, the Wright brothers, Jobs, and Gates were more than inventors; they were savvy businessmen who understood their environments. For instance, Edison did not invent the first incandescent light bulb, but his bulb lasted longer with its carbonized thread. His real innovative success was the introduction of a central power plant with generators, voltage regulating devices, and copper wires to create a commercial market for the light bulb.[47] The Wright brothers were not the only inventors working on a flying machine when the Wright Flyer first flew, but it was a contract with the Army in 1907 that commercialized the success of the aircraft.[48] Xerox Palo Alto Research Center created the mouse and Graphical User Interface, but Steve Jobs recognized the significance of the inventions and integrated them with the personal computer.[49] IBM was working on its own operating system called Top View in 1985 while VisiCorp had already released an operating system in 1983 called VisiOn that contained the first PC-based Graphical User Interface.[50] Gates and Allen would not release Windows 1.0 until 1985, but Microsoft is running on 91 percent of computers worldwide.[51]

Sustaining vs. Disruptive Technologies

Advocates for increasing the number of STEM-credentialed graduates often link U.S. innovation to economic prosperity. A common misperception is that the next innovation breakthrough will result in significant economic gains for the organization, company, or country that creates it. Clayton Christensen addresses this fallacy in *The Innovator's Dilemma* by offering an explanation of why successful companies fail to stay on top of their industries when confronted by certain markets and technological change.[52] Christensen argues that successful companies are led by talented managers who focus on developing sustaining technologies rather than on what he calls disruptive technologies. Sustaining technologies are characterized by improving on established product performance by making incremental improvements. Disruptive technologies, however, typically underperform established products in mainstream markets, but have other features that customers value such as being cheaper, simpler, smaller, and frequently more convenient to use.[53] Disruptive technologies will eventually overtake or match the performance of the sustaining technology based on market demand. Conversely, sustaining technologies will focus on product improvements that may be beyond what the market demands. In other words, managers of successful top companies may invest heavily to improve their existing product and later discover that the improvement outstrips market demand. Apple's iPhone and Samsung's Galaxy provide a good illustration of disruptive and sustaining technologies in the smartphone market.

Steve Jobs did not invent the cellphone, MP3, hand-held computer, or digital camera, but he did recognize that integrating these devices would revolutionize the portable electronics industry. Apple released the first-generation iPhone in 2007 and rapidly became the market leader in the smartphone and consumer electronics technology. The first-generation iPhone represented a disruptive technology because it was less expensive to purchase the capabilities individually. The first-generation iPhone did not include available technologies such as the Global Positioning System that may be found in other smartphones. Since 2007, Apple has invested in sustaining iPhone technology by releasing newer generations that included faster processors, better cameras, and improved navigation.[54] Korean electronics giant Samsung challenged Apple's lead position in 2011 when the company flooded the market with myriad products such as cellphones, smartphones, and tablets in a short period of time to appeal to low- and high-end markets.[55] Samsung's strategy appears to have been particularly successful with lower end markets, as evidenced by the company's market share doubling to more than 36 percent in the second quarter of 2011 from about 18 percent during the same period the previous year.[56] Samsung introduced a disruptive technology; its strategy was to cater to those markets that wanted a less expensive and possibly less capable smartphone.



Replica of Sputnik 1 (U.S. Air Force)

Apple lost a considerable share of the smartphone market by investing in a sustaining technology while Samsung invested in disruptive technology by developing a less expensive and capable product to create a new market. Christensen argues that large, well-managed companies fail to invest in disruptive technologies for a number of reasons. First, successful companies depend on customers and investors for resources and are reluctant to seek lower margin opportunities that their customers do not want.[57] Second, small markets do not solve the growth needs of large companies. Third, markets that do not exist cannot be analyzed. Prior to making a significant investment, companies often want to understand the environment and likelihood of success. Since disruptive technologies are entering emerging markets, the environment is not well understood, and therefore large successful companies are reluctant to enter. Fourth, an organization's capabilities define its disabilities. There is a tendency in successful organizations to develop high-margin over low-margin products. Finally, technology supply may not equal market demand. Companies developing sustaining technologies follow a trajectory of improvement that often ends up overshooting mainstream market needs and creating a vacuum where competitors can enter.[58]

A STEM-Literate Approach

STEM-credentialed personnel are needed in the workforce, but they are not the sole source of innovation. Rather than creating new innovations, this segment of the workforce tends to focus on sustaining technologies. Instead of focusing on sustaining technologies, a U.S. policy is needed that creates a STEM-literate workforce. In *David and Goliath: Underdogs, Misfits, and the Art of Battling Giants*, Malcolm Gladwell claims that more than half of college students who start a STEM degree program change their majors. STEM advocates may point to this statistic as an education failure to prepare college-bound students in these courses of study and demand further funding of high school STEM education. Instead of increasing high school funding for STEM education, we should incentivize STEM literacy and innovation.

One reason that college students do not pursue STEM degrees or drop out of the programs is that graduates can earn more money in service-related industries such as health care, finance, and law. A STEM-literate policy recognizes the financial incentive for entering these industries and provides graduates a broader background in STEM disciplines. Literate graduates entering service industries would understand STEM without having to commit to 4 years of study.

The United States should not directly compete with countries such as China and India on the number of STEM college graduates, but instead should leverage its own strengths such as leading university systems, an entrepreneurial culture, U.S. intellectual property rights protection, and natural resources to foster innovators. A STEM-literate policy would create graduates who can improve publishing technologies, business majors who can develop predictive economic indicators, and economics graduates who understand the human genome.

The government has significant leverage to encourage STEM literacy using

Federal funding such as Pell Grants. President Barack Obama's fiscal year 2014 budget request included $29.9 billion in Pell Grant funding.[59] A condition for Federal financial aid would include a requirement for students to successfully complete STEM-literate courses. Universities could tailor these courses for non-STEM majors and create degree tracks that encourage innovation. College Level Examination Program tests could be created to allow high school students to test out and still receive Federal aid. These tests would serve as an incentive for college-bound high school students to complete STEM courses prior to high school graduation. A policy that creates STEM-literate graduates creates a workforce capable of developing innovative solutions by integrating multiple disciplines. **JFQ**

Notes

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